Transforming NOAA Water Resources Prediction

Presented to

Northeast Climate Update: National Water Model

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Stakeholder Priorities

| Flooding | Drought | Water Availability | Water Quality | Climate Change |

Need integrated understanding of near- and long-term outlook and risks

- **Provide consistent, high resolution ("street level") analyses, predictions and data to address critical unmet information and service gaps**

- **Transform information into actionable intelligence by linking hydrologic, infrastructural, economic, demographic, environmental, and political data**

Integrated Water Prediction
Setting the Stage for Transformation

Centralized Water Forecasting Demonstration (2015)	Enhanced Water Prediction Capability (2016)	Integrated Water Prediction (2017 Omnibus)
• National Water Model (NWM) Development and Demonstration • Centralized Water Resources Data Services • Water Resources Test and Evaluation Service	• Hyper-Resolution Modeling • Real-Time Flood Forecast Inundation Mapping • Enhance Impact-Based Water Resources Decision Support Services	• Stand up the National Water Center Operations Center/New service delivery model • Increase high performance computing capacity • Couple terrestrial freshwater and coastal estuary models for total water predictions in the coastal zone

A Catalyst to Transform NOAA's Water Prediction Program

- **Center of excellence for water resources science and prediction; catalyst for Enterprise Collaboration**

- **Operations Center for water resources common operating picture and decision support services**

  - **Hiring process for initial 12 staff underway**

  - **WPOD Director selected**

  - **Initial 14x7 operations by the end of CY19**

  - **Successful demonstration of RFC service backup capability**

NWC has hosted more than 70 scientific meetings with over 2600 participants

NWC Annual Innovators Program

Partnership with the academic community via Interagency Agreement with the **NSF** and **CUAHSI** to host a competitive **Summer Institute**

- **Year one** included 44 graduate students from 19 Universities, June - July 2015
  - Demonstrated ability to **simultaneously model the entire continental United States** river network at high spatial resolution, in near real-time for 2.7 million stream reaches
- **Year two** included 34 graduate students from 21 Universities, June - July 2016
  - Demonstrated the ability to generate **flood inundation maps** utilizing NWM output
  - **Engaged social scientists and stakeholders from the EM Communities** to explore ways to best communicate flood information
- **Year three** includes 34 graduate students from 25 Universities, June - July 2017
  - Refine the recently developed process to create **flood inundation maps** nationally in real time
  - Develop a strategy for a **hyper-resolution nest** of the NWM
- **Year four** includes 33 graduate students from 28 Universities, June - July 2018
  - Explore shallow aquifer/groundwater coupling in the NWM
  - Continue Hyper-Resolution model development with emphasis on hydraulic solutions
  - Add two new tracks on citizen science in water resources, and computer science in water models
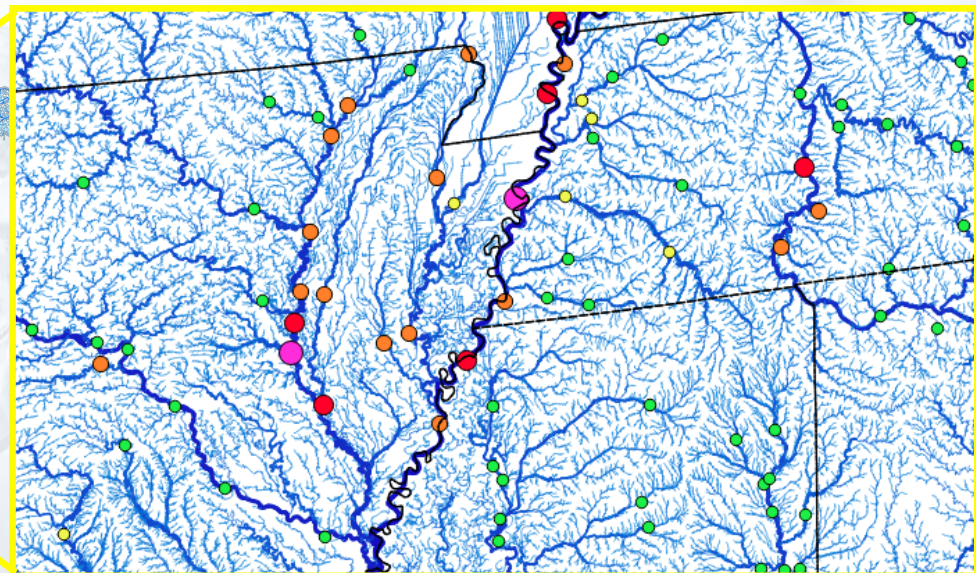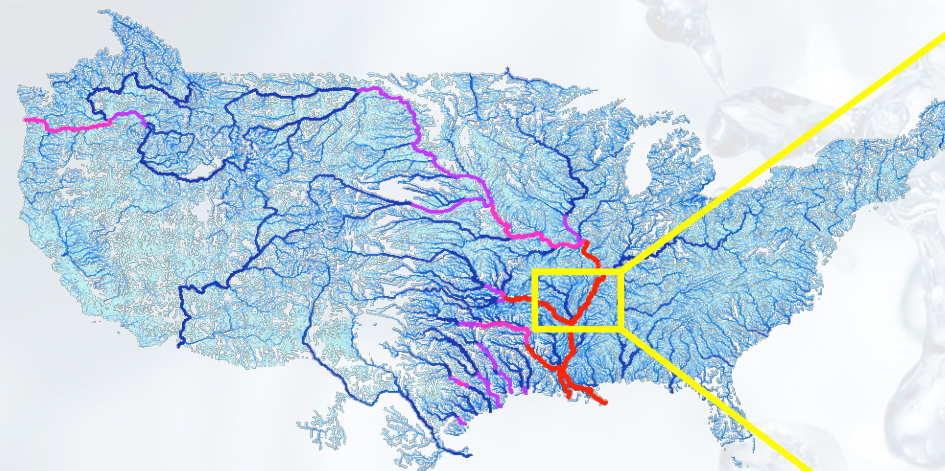
National Water Model
*Initial Operating Capability – v1.0 implemented August 16, 2016*

- **Spatially continuous estimates of major water cycle components** (e.g., snowpack, soil moisture, channel flow, major reservoir inflows, flood inundation)

- Operational forecast **streamflow guidance for currently underserved locations**: 3,600 forecast points ⟶ 2.7 million NHDPlus river reaches (700 fold increase in spatial density)

- Employs an **Earth system modeling architecture** that permits rapid model evolution of new data, science and technology (i.e. **WRF-Hydro**)

Current NWS River Forecast Points overlaid with NWM Stream Reaches

NCAR — NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

OWP | OFFICE OF WATER PREDICTION

National Water Model Description: WRF-Hydro Modeling System
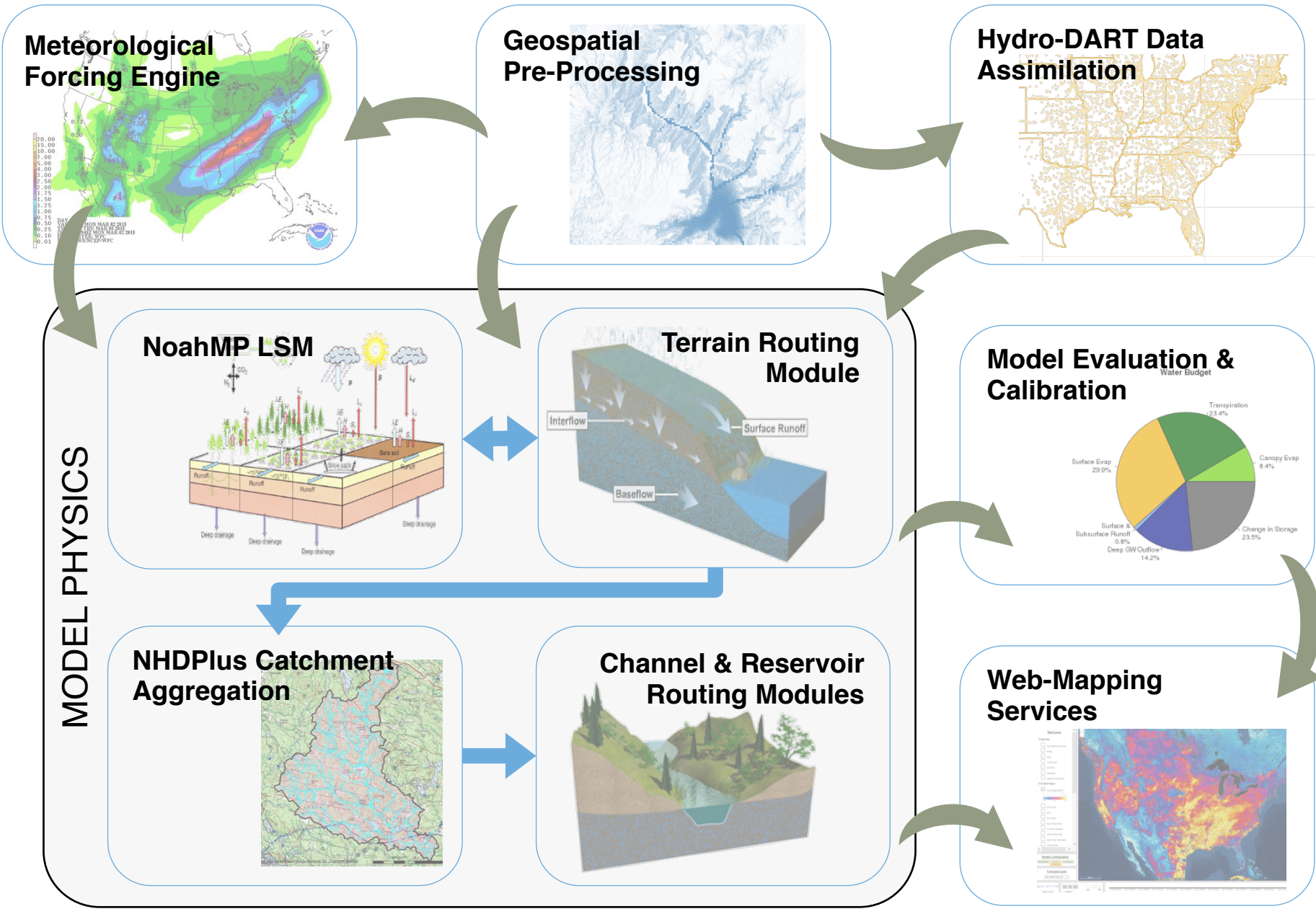
National Water Model V1.1/V1.2
Analysis and Forecast Operational Cycling Configurations

	Cycling	Forecast	Forcing	Outputs
Analysis & Short-Range	Hourly	18 hours	MRMS QPE Downscaled HRRR/RAP Blend	1km Land States, 250m Sfc Routed Water, NHDPlus Streamflow
Medium-Range	4 x Day	10 days	Downscaled Global Forecast System (GFS)	1km Land States, 250m Sfc Routed Water, NHDPlus Streamflow
Long-Range	Daily Ensemble (16 members)	30 days	Downscaled and Bias-Corrected Climate Forecast System (CFS)	1km Land States, NHDPlus Streamflow

Analysis assimilates ~7,000 USGS Observations

All configurations include reservoirs (1200+ water bodies parameterized with level pool scheme)

Movie (slide show to view)
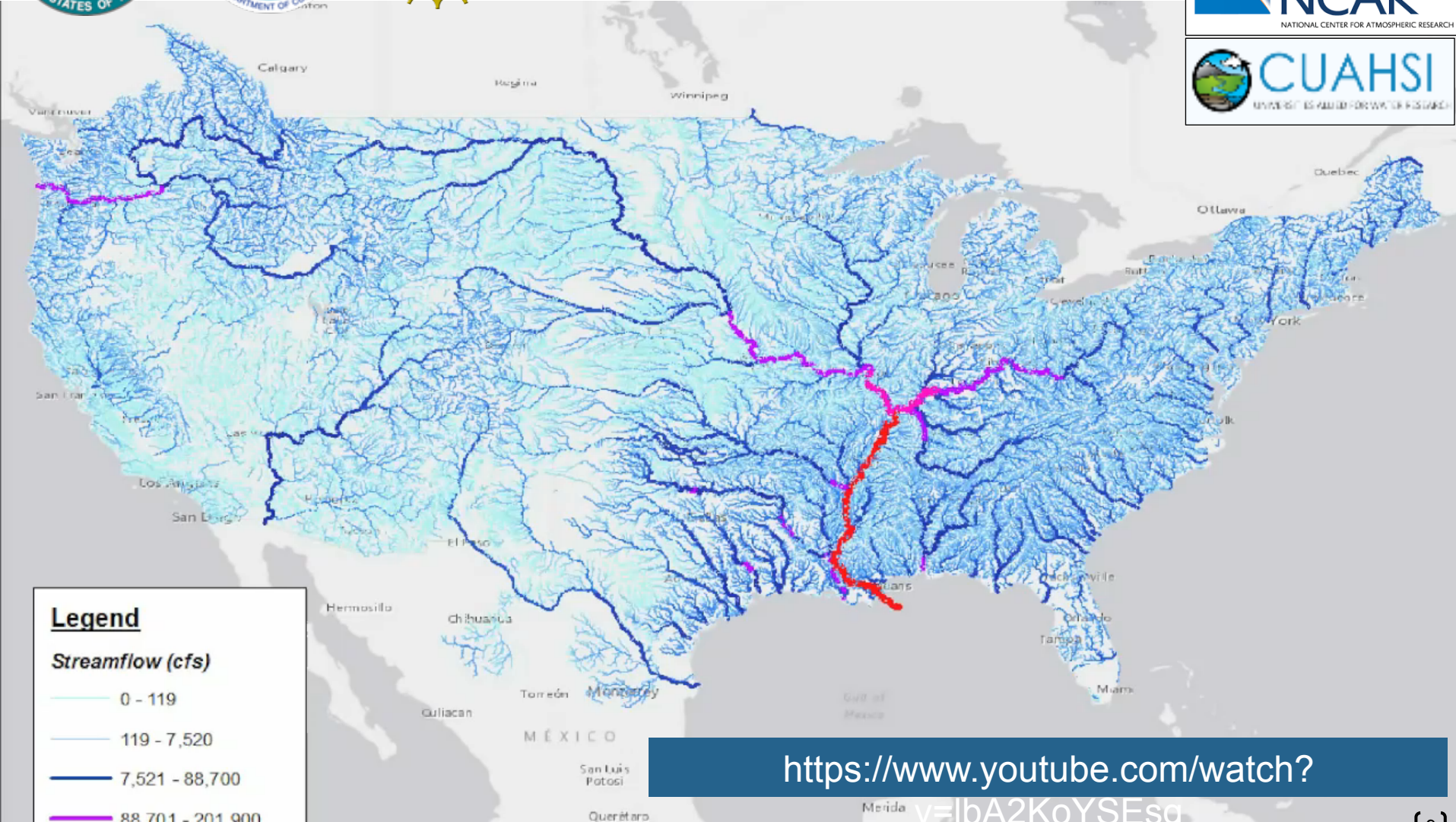
Upgrading to NWM V2.0 and Beyond

v1.0 → v1.1 → v1.2

**Foundation Established
August 2016**
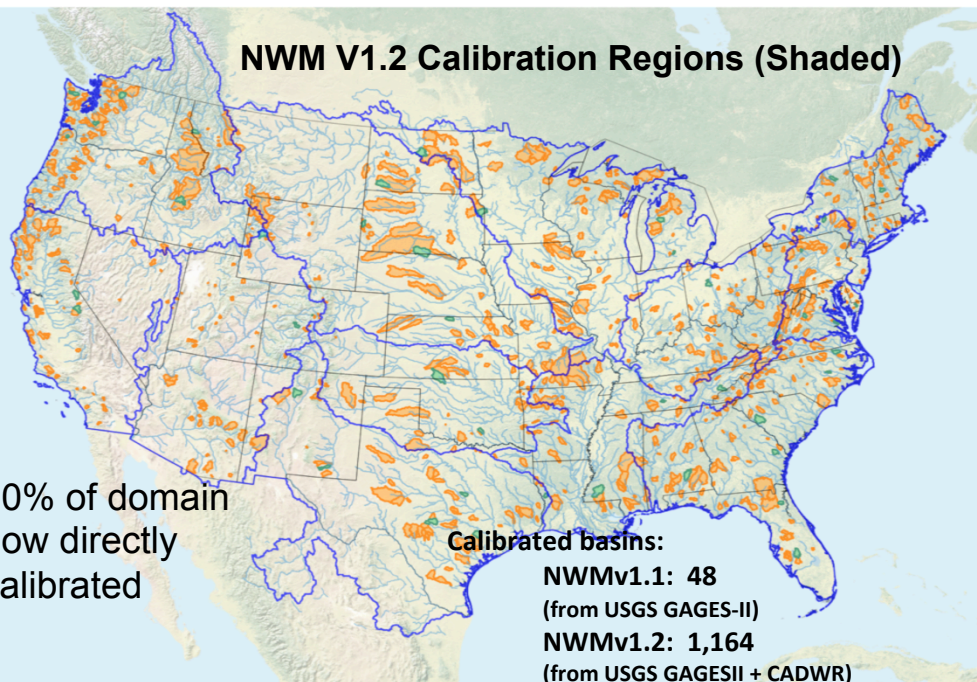Water Resource Model for 2.7 Million Stream Reaches

**First Upgrade
May 2017**
Increased cycling freq. and forecast length, initial calibration, improved soil/snow physics

**Second Upgrade
March 2018**
Extensive calibration, improved hydrofabric (terrain and stream connections), improved data assimilation

NWM V1.2 Calibration Regions (Shaded)

10% of domain now directly calibrated

Calibrated basins:
NWMv1.1: 48
(from USGS GAGES-II)
NWMv1.2: 1,164
(from USGS GAGESII + CADWR)

V2.0 (Winter 2018-19): Ensemble medium range forecast, Hawaii domain, longer Analysis period driven by hourly MPE blend, targeted calibration, increased code modularity for community development

Beyond V2.0: Water regulation, coastal coupling, hyper-res modeling, Great Lakes, Puerto Rico and AK domains
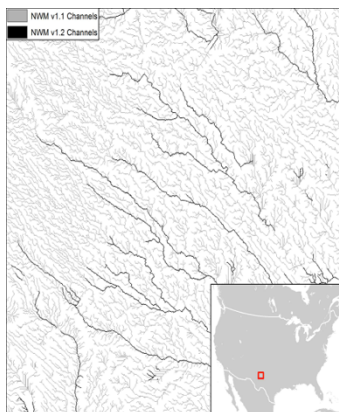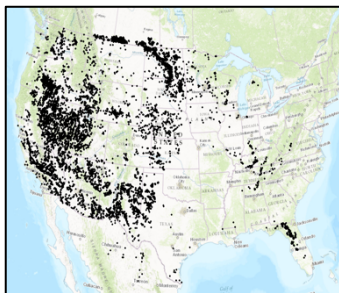
NWM V1.2 Parameter and Data Improvements

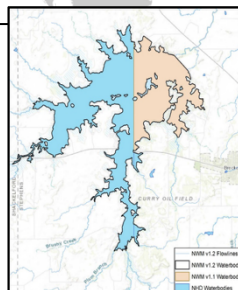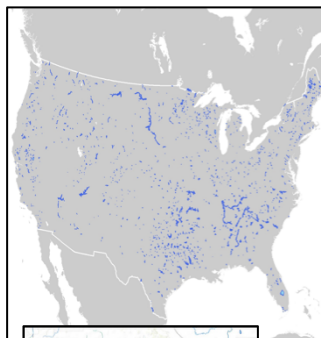### oCONUS Coverage Improvements
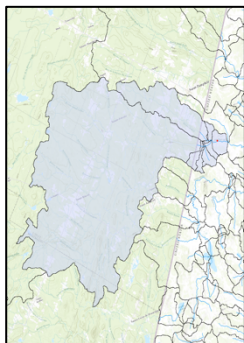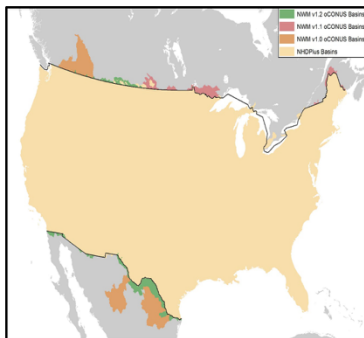
Improved oCONUS coverage in Canada & Mexico
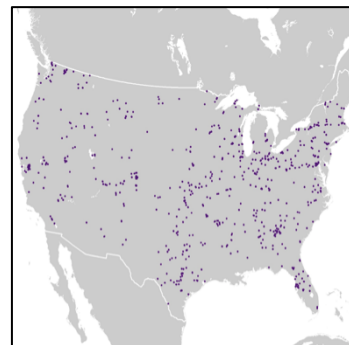
DEM & Channel Harmonization

Used higher resolution DEM source data to improve underlying network parameters
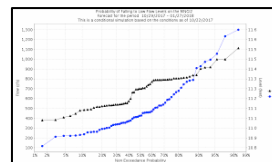
Reservoir Improvements

Added or altered 328 reservoirs, improved reservoir parameters

Gauge Additions and Network Improvements

Added 680 new USGS gages, corrected gauge locations, removed tidally-influenced gages, fixed stream breaks

Dynamic Parameter Updates

Added hooks to enable on-demand automated updates of improved hydrologic and land surface parameters

- These improvements often have large local impacts that are not represented in regionally-computed statistics

Experimental NWM-based Guidance for Hurricane Harvey
Flood Inundation Maps based upon the NWM Analysis and 5-Day Forecast

- **Maps supported emergency management efforts to stage supplies in non-flooded areas and to target relief efforts**

- **TDEM needed information on exisiting and maximum possible flood extent**

National Water Model Medium-Range Forecast

National Water Model Analysis

NWM Streamflow Forecast with GFS Precipitation Overlay

NWM Streamflow Analysis with MRMS Precipitation Overlay
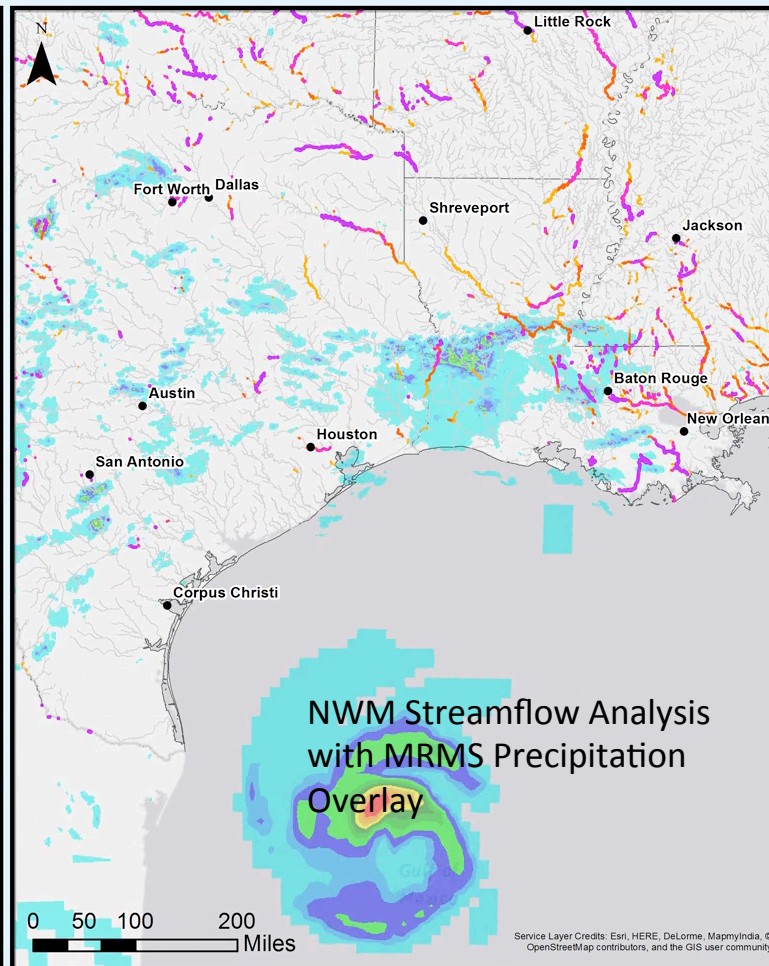
Hurricane Harvey

These maps present a comparison of the Medium-Range Forecast (left panel) and Analysis (right panel) from the National Water Model v1.1.

High Flow Potential

— Major Potential for High Flow (> 200% over bankfull flow)
— Moderate Potential for High Flow (100 – 200% over bankfull flow)
— Minor Potential for High Flow (50 – 100% over bankfull flow)
— Near Bankfull Flow (0 – 50% over bankfull flow)
— National Water Model Streams
● Major U.S. Cities
☐ U.S. State Boundaries

Hourly Precipitation (inches)

0   1   2   3   > 6

Reference Time: 2017-08-22 12:00 UTC
Valid Time: 2017-08-25 00:00 UTC

Valid Time: 2017-08-25 00:00 UTC
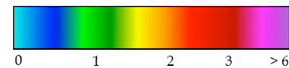
Overall extreme streamflow pattern forecast several days in advance by NWM

- ## NOAA's Water Services are Evolving
  - We are building a foundation for change
  - Continental scale modeling approach producing consistent, "street-level" information to address growing stakeholder needs
  - Stakeholder input will continue to inform future science/service development activities
  - Deliver comprehensive, integrated actionable water predictions/intelligence
  - More than streamflow -- spatially-continuous forecasts of soil moisture, evapotranspiration, runoff, snow water equivalent and other parameters

- ## Implementing State-of-the-Art Technical Approach
  - Water resources prediction through state-of-the-science earth system modeling in a high performance computing environment
  - Impact-based decision support services underpinned by geo-intelligence

- ## New Organization, Cornerstone Facility and Philosophy
  - Office of Water Prediction/National Water Center
  - Collaboration across NOAA and with Federal Partners, Academia, and the broader Water Resources Enterprise is critical to success

Vision without action is merely a dream.   Action without vision just passes the time. Vision with action can change the world.
Joel A. Barker